ORIGINAL

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's	)	
Rules Regarding Ultra-wideband	)	ET Docket No. 98-153
Transmission Systems	)	

Reply Comments

M/A-COM, a division of AMP, Inc., submits these reply comments in response to comments filed on December 7, 1998 in the above-captioned proceeding.

Summary of Position

- M/A-COM supports the Commission's proposal to modify the Part 15 rules to permit the operation of ultra-wideband (UWB) devices on an unlicensed basis. This includes permitting non-interfering intentional emissions within restricted bands.

- A definition of UWB devices should distinguish between those devices that operate below 10 GHz and those which operate above 10 GHz. The wide bandwidths available for UWB devices above 10 GHz can achieve the same benefits without needing the large fractional bandwidths that are needed by UWB devices below 10 GHz. But low power intentional emissions in restricted bands must be permitted.

- The Commission should relax the rules that now require use of a Pulse Desensitization factor, as this protection is not applicable to UWB devices, nor required to protect other technology from UWB transmissions. Similarly, the 20 dB limit on peak to average ratio should not apply to UWB devices.

- Finally, regulations should be based on power density rather than total power or field strength, because the potential for interference into restricted bands is due only to the portion of the emitted signal that falls within those bands.

M/A-COM's Interest in This Proceeding

M/A-COM's interest in this proceeding differs from that of most others responding, because our UWB products operate above 10 GHz in the millimeter wave range rather than below 10 GHz. Consequently, the focus of our recommendations may differ from the comments of others.

M/A-COM is developing a 24 GHz high-resolution radar sensor for use by automobile manufacturers for Object Detection Systems on motor vehicles. The detection system assists drivers in the prevention of accidents by dealing with typical driving scenarios. This High Resolution Radar, employing UWB techniques and occupying a bandwidth of approximately 3 to 4 GHz, is able to achieve such high quality object resolution for safety features that other vehicular radars cannot provide. The result is substantial public interest benefits in everyday driving scenarios such as

- Blind Spot Object Detection;
- Parking Aid and Backup Object Detection;
- Short Range Autonomous Cruise Control -- Stop and Go;
- Pre-Crash Alert information for pre-tensioning seat belts and pre-arming other vehicle safety systems.

Introduction

These reply comments are based upon a review of industry comments, provided on December 7, 1998, in response to the FCC, Notice of Inquiry ("Notice"), FCC 98-208, released September 1, 1998.

A large number of the respondents concur with M/A-COM's position that minor changes to the existing Part 15 regulation would allow the introduction of numerous UWB products with great positive societal impact. We believe that UWB technology is widely employed in Federal Government programs. But without changes to the Commission's Rules, the commercial

introduction of this emerging technology will be impossible, and affordable products with the robust capabilities of UWB devices will be denied to the public.

In our reply comments, we recommend a definition of UWB devices; we support the numerous proposals that use of a Pulse Desensitization Factor be eliminated; we propose that the 20 dB peak-to-average ratio requirement be eliminated for UWB devices; and we support the use of power density rather than total power or field strength for determining the potential for interference into restricted bands.

These proposals are consistent with the high-resolution radar product that M/A-COM is developing for automotive application in the millimeter wave range around the 24 GHz ISM band, and are also generally consistent with the views of those developing products operating below 10 GHz.

Definition for Ultra-Wideband (UWB) Devices

At frequencies below 10 GHz, the record in this proceeding generally supports the notion that a UWB signal should occupy a bandwidth equal to a large percentage, at least 25%, of the carrier frequency. Most parties, for example, cite the 1990 DARPA report[1] as a basis for the 25% fractional bandwidth.

For higher frequencies, on the other hand, there is no similar record in support of any particular fractional bandwidth. At these higher frequencies, the benefits of UWB technology may be achieved with a lower fractional bandwidth than at lower frequencies. The occupied bandwidths of such devices may be very large indeed at these higher frequencies, even though the fractional bandwidths are not as large. Consequently, the same policy issues (primarily, the permissibility of intentional RF emissions in restricted bands) arise when devices at these higher frequencies seek to achieve the same technical and operational benefits as UWB devices at lower frequencies.

[1] Assessment of Ultra-Wideband (UWB) Technology, OSD/DARPA Ultra-Wideband Radar Review Panel, R-6280 (July 13, 1990).

In light of these considerations, M/A-COM proposes that the FCC adopt the following definition for an ultra-wideband signal:

> *Ultra wide-band signal.* An ultra wide-band signal is an intentionally radiated signal designed to have a bandwidth to be equal to at least 25% of the fractional bandwidth below 10 GHz carrier frequency, and at least 2.5 GHz above 10 GHz carrier frequency.

The term "fractional bandwidth" should be defined in the Commission's Rules as follows:

> *Fractional bandwidth.* The bandwidth defined by the expression $2(f_H - f_L) / (f_H + f_L)$ in which f_H is the highest and f_L is the lowest frequency limit marking the frequencies that are 20 dB below the maximum of the power spectral density envelope of the UWB signal.

The term "carrier frequency" should be defined in the Commission's Rules as follows:

> *Carrier frequency* is defined by the expression $(f_H + f_L)/2$, where f_H is the highest frequency and f_L is the lowest frequency limit marking the frequencies that are 20 dB below the maximum of the power spectral density envelope of the UWB signal.

As a general principle, ultra-wideband devices should be restricted to power levels and field strengths that are consistent with other devices regulated under Part 15 of the Commission's Rules on an unlicensed basis. However, as discussed in more detail below, technical regulations needed to protect against interference into restricted bands must recognize the widely varying bandwidths of restricted bands and must therefore be based on power density rather than total power or field strength.

Pulse Desensitization Factor

By using the *Pulse Desensitization Factor,* one can calculate the peak pulse power after performing a spectrum analyzer measurement. Since a spectrum analyzer measurement is a time average, by applying the PDF correction the worst case transient interference can be estimated for *rectangular* pulses. Unfortunately, practical limitations on an UWB pulse will severely distort the pulse shape even if originally it was intended to be rectangular. Such pulse shape distortions are inevitable given the extreme wide bandwidths under consideration. Furthermore, the application of the PDF requires accurate knowledge of the actual operating UWB pulse length and that length will be difficult to measure directly for pulses shorter than 1 nsec. The appropriate application of the pulse desensitization factor to field disturbance sensor power measurements is, therefore,

ambiguous. Consequently, it will afford no real protection to equipment interference levels and the rules for application will not be clear.

The interference potential into a narrow bandwidth receiver will *always* be proportional to the energy spectral density distribution of the jamming signal, and for recurring transmissions be proportional to that of the power spectral density distribution. The narrow band receiver will turn the wide band jamming signal into a nearly sinusoidal oscillation on the time scale of the UWB pulse, and the power of this oscillation is proportional to the spectral density of the UWB signal. Its interference effect being dependent on the pulse shape only indirectly, the appropriate measure of the potential jamming strength is the spectral density distribution thus rendering the *pulse desensitization factor* not relevant.
To avoid physical damage to sensitive high gain receivers, it is recommended that the FCC regulate the absolute maximum peak field intensity emitted from an UWB.

FCC Rules might allow a peak EIRP that is dependent upon the frequency of operation and the particular application. Devices such as ground penetrating radar use lower frequencies, typically below 2 GHz, and the signal is aimed at the ground. In general these will need higher peak power than millimeter wave UWB devices that radiate in the air. The latter could be limited to 10 W peak EIRP, while the former may need 10 kW peak EIRP.

Peak to Average Ratio

The current limitation of a 20 dB peak to average ratio should not apply to UWB devices. Notwithstanding the comments by Time Domain Corporation, it is difficult to see that operation in excess of 20 dB peak to average power is threatening to the operation of other equipment, unless the peak power itself is high enough to be a threat. More appropriate would be a limit on peak power and a separate limit on average power spectral density irrespective of duty cycle. A peak power limit would also be consistent with the existing 250 mV per meter field strength limit of the existing field disturbance sensors operating within the 24 GHz ISM band.

To control possible interference into conventional non-UWB devices, the appropriate measure of the interfering emission should be the time average energy density per unit bandwidth (Hz) for pulsed transmission. To assure "noise-like" behavior, the FCC could prohibit periodic pulse emission and require that the pulse timing be randomized. This form of regulation should also alleviate the need for the "20 dB" rule as currently applied to Part 15 devices.

A minimum of 10 kHz average pulse repetition rates seems to be appropriate, but the pulse width and duty cycle could be left arbitrary. The time averaged EIRP spectral density could be limited to 50 to 500 μW/GHz = 50 to 500 nW/MHz, again dependent on the application.

Regulations Should Be Based On Power Densities Rather Than Power or Field Strength

As noted above, M/A-COM has a particular interest in products that operate around 24 GHz, with bandwidths of 3 to 4 GHz. Under current regulations, restricted band operation is limited to spurious emissions at electric field strength levels less than 500 μV per meter, at a range of three meters, independent of the bandwidth of the emitter. There are three restricted bands near the 24 GHz ISM band, with vastly different bandwidths:

17.70 to 21.40 GHz
22.01 to 23.12 GHz
23.60 to 24.00 GHz

The interference potential in restricted bands comes only from the power emitted within these bands, not from the entire power that is spread across the entire bandwidth of the emitter. Consequently, the field strength limit that now appears in the Commission's Rules, which is based on the entire power of the emitter, is not relevant for the determination of interference potential. Commission regulations should define the limits of intentional and spurious emissions based solely on emitted average and peak power spectral densities within the bands, rather than total power or field strength.

Finally, through the establishment of a coherent set of regulations governing low power UWB devices, the FCC should remove the distinction between intended and unintended radiating

devices, since there is no difference in the potential interference between intentional and unintentional emissions.

Conclusion

In light of these considerations, the Commission should permit the operation of UWB devices on an unlicensed basis under Part 15 of its rules. It should recognize that above 10 GHz, the fractional bandwidth need not be as large as below 10 GHz to achieve the benefits of UWB technology. Current regulations on Pulse Desensitization Factor and peak to average ratio should not apply to UWB devices. Regulations should be based on power densities rather than total power or field strength.

Respectfully submitted,

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